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METEOROLOGY.—*On the effect of vertical convection on lapse rates.*[1] C.-G. ROSSBY, Massachusetts Institute of Technology. (Communicated by EDGAR W. WOOLARD.)

Because of the dynamic (adiabatic) heating or cooling which accompanies vertical motion of air in the earth's atmosphere, the occurrence of convectional movements will in general result in a modification of the lapse rates that exist prior to such convection. The following treatment of this effect, which is believed to be new, is shorter and simpler, and in several respects more satisfactory, than that customarily given.[2]

Let T be the absolute temperature, θ the potential temperature, ρ the density, and dT/dz the lapse rate within an infinitesimal stratum of dry air of thickness dz and cross section q. Suppose the stratum to undergo a vertical displacement, due to convectional movements; and let T_0, θ, q_0, ρ_0, $(dT/dz)_0$, dz_0, denote the values of the preceding quantities before the displacement, and T_1, θ, q_1, ρ_1, $(dT/dz)_1$, dz_1, those after the displacement; the potential temperature θ remains constant, the process being assumed adiabatic. Denote the lapse rate before displacement by $-\alpha_0$, that after displacement by $-\alpha_1$; and put $\gamma = Ag/c_p$, where A is the reciprocal of the mechanical equivalent of heat, c_p is the specific heat at constant pressure and g is gravity. The potential temperature is given by

$$\theta = T\left(\frac{p}{P}\right)^{-\frac{AR}{c_p}},$$

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[1] Received November 19, 1929.

[2] F. M. EXNER. *Dynamische Meteorologie.* 2te aufl., pp. 57–59, 85–86. 1925. W. J. HUMPHREYS. *Physics of the Air.* 2 ed., pp. 36–37. 1929.

in which p is the barometric pressure, P is the standard pressure, and R is the characteristic gas constant. Differentiating this equation, we have

$$\frac{d\theta}{dz} = \frac{\theta}{T}\left\{\frac{dT}{dz} - \frac{ART}{pc_p}\frac{dp}{dz}\right\}.$$

Substituting $dp = -\rho g dz$ gives

$$\frac{d\theta}{dz} = \frac{\theta}{T}\left\{\frac{dT}{dz} + \frac{Ag}{c_p}\right\},$$

whence

$$\left(\frac{d\theta}{dz}\right)_0 = \frac{\theta}{T_0}(\gamma - \alpha_0), \tag{1}$$

$$\left(\frac{d\theta}{dz}\right)_1 = \frac{\theta}{T_1}(\gamma - \alpha_1), \tag{2}$$

The constancy of mass requires that $\rho_0 q_0 dz_0 = \rho_1 q_1 dz_1$, or

$$\frac{dz_0}{dz_1} = \frac{\rho_1 q_1}{\rho_0 q_0} = \frac{p_1 q_1 T_0}{p_0 q_0 T_1}.$$

Now

$$\frac{d\theta}{dz_1} = \frac{d\theta}{dz_0}\frac{dz_0}{dz_1} = \frac{d\theta}{dz_0}\frac{p_1 q_1 T_0}{p_0 q_0 T_1}. \tag{3}$$

Multiplying (1) by $\frac{p_1 q_1 T_0}{p_0 q_0 T_1}$ gives, by (3),

$$\frac{d\theta}{dz_1} = \frac{\theta}{T_0}(\gamma - \alpha_0)\frac{p_1 q_1 T_0}{p_0 q_0 T_1}. \tag{4}$$

Eliminating $d\theta/dz_1$ between (4) and (2), we have

$$\frac{\theta}{T_0}(\gamma - \alpha_0)\frac{p_1 q_1 T_0}{p_0 q_0 T_1} = \frac{\theta}{T_1}(\gamma - \alpha_1),$$

or

$$\gamma - \alpha_1 = \frac{p_1 q_1}{p_0 q_0}(\gamma - \alpha_0). \tag{5}$$

In particular, if $q_1 = q_0$, we get from (5)

$$\left(\frac{dT}{dz}\right)_1 = \frac{p_1}{p_0}\left\{\left(\frac{dT}{dz}\right)_0 + \frac{Ag}{c_p}\right\} - \frac{Ag}{c_p}.$$

The explanation of subsidence inversions is apparent from these equations.

The equation of continuity furnishes an adequate expression for the variation in dz.

GEOLOGY.—*The Cretaceous faunas in the section on Vermilion Creek, Moffat County, Colorado.*[1] JOHN B. REESIDE, JR., U. S. Geological Survey.

Some years ago the writer assisted Messrs. J. D. Sears and W. H. Bradley in studying the unusually complete stratigraphic section along Vermilion Creek, in T. 10 N., R. 101 W., Moffat County, Colorado. Mr. Sears later published[2] a description of the lithologic units together with correlations based on areal studies, on stratigraphic and lithologic considerations, and on the fossils found. The regional sequence of rocks from pre-Cambrian to Eocene is present. No detailed statement of the species of fossils observed in the section has been published, however, and it is the chief purpose of this paper to record in some detail the collections from the Cretaceous beds.

The nomenclature applied to the Cretaceous beds of Vermilion Creek is that derived from southwestern Colorado: Dakota (?) sandstone, Mancos shale, and Mesaverde group, though only part of the last is exposed, a fault having carried the higher Cretaceous rocks far below the present surface. The locality is close enough to southern Wyoming, however, to show some of the stratigraphic subdivisions generally accepted in that region. As Mr. Sears has noted in the report cited above and in a later one,[3] the Mancos shale contains at the base a thin member similar to the Aspen and Mowry shales in its peculiar lithology and its fossil content; resting upon the basal member a thin sandstone similar in lithology and fossil content to beds at some places included in the Frontier formation; and upon it a thick shale member corresponding to the Hilliard shale in position, though including in the upper part shaly marine equivalents of part of the coal-bearing rocks that farther northwest would not be included in the Hilliard shale.

[1] Received January 4, 1930. Published with the permission of the Director of the U. S. Geological Survey.

[2] J. D. SEARS. *Geology and oil and gas prospects of part of Moffat County, Colorado, and southern Sweetwater County, Wyoming.* U. S. Geol. Surv. Bull. 751: 278–281. 1924.

[3] J. D. SEARS. *Geology of the Baxter Basin gas field, Sweetwater County, Wyoming.* U. S. Geol. Surv. Bull. 781: 15–22. 1926.

In terms of the section east of the Rocky Mountains the Mancos of Vermilion Creek includes equivalents of the Graneros, Greenhorn, Carlile, Niobrara, and lower Pierre formations, the last containing representatives of the Eagle and Telegraph Creek beds. In terms of the European classification it is the Turonian, Coniacian, Santonian, and lower Campanian, possibly extending also into the upper Campanian. The part of the overlying Mesaverde group present is probably equivalent to the middle part of the Pierre or upper Campanian, though very few fossils are available as a basis for an opinion. In summary form the section of the Mancos may be interpreted as follows, the unit numbers referring to the detailed section given below:

European equivalent		*Feet.*		*Equivalent in Plains Region*	
Campanian:					
Upper(?):	No. 1, fossiliferous	100			Lower part of Pierre shale
	No. 2 (part), fossiliferous	489			
	No. 2 (part), barren	735	1324		
Lower:	No. 3, fossiliferous	140		Eagle sandstone	
	No. 4 (part), fossiliferous	200			
	No. 4 (part), barren	816	1156		
Santonian:					
Upper:	No. 4 (part), fossiliferous		886	Tel. Creek formation	
Lower:	No. 4 (part), fossiliferous	383		Niobrara formation	
	No. 5, fossiliferous	75			
	No. 6, fossiliferous	75	533		
Coniacian:	No. 7, fossiliferous	320			
	No. 8, fossiliferous	430			
	No. 9, fossiliferous	106	856		
Turonian:					
Upper:	No. 10, fossiliferous	1		Carlile shale (Frontier of authors)	
	No. 11, barren	315			
	No. 12, barren	2			
	No. 13, barren	4			
	No. 14, fossiliferous	55			
	No. 15, barren	25			
	No. 16, fossiliferous	54			
	No. 17, barren	1	457		

Lower:	No. 18, fossiliferous.....	34		
	No. 19, barren.....	3		Greenhorn-Graneros
	No. 20, fossiliferous.....	118	155	(Aspen of authors)
		Total	5367	

It is notable that the Turonian *Prionotropis woolgari* fauna, which should appear between that containing *Metoicoceras whitei* and that containing *Prionocyclus wyomingensis*, was not found in this section and that there is little room for it. It is possible that the sediments which represent the time of the *woolgari* fauna are very thin or lacking, though there is no particular physical evidence of a hiatus. The fauna in the lower part of the Niobrara equivalent (Coniacian), containing *Inoceramus deformis, Baculites codyensis, Phlycticrioceras oregonense*, etc., is much like that described by the writer from the lower part of the Cody shale of northern Wyoming.[4] The very large shells of *Inoceramus* (*Haploscapha?*), mostly represented by fragments coated with *Ostrea congesta*, are abundant in the Niobrara equivalent and extend above it into the Telegraph Creek equivalent (upper Santonian) only in a scarcer and depauperate development. In some parts of the section specimens more than four feet in maximum dimension were seen in cross section. In the upper part of the Mancos shale fossils are extremely rare and extended search yielded only a few scattered species, except in the sandstone lenses at the top of the equivalent of the Eagle sandstone (lower Campanian), where a more extensive and significant fauna occurs.

The detailed section is as follows:

CRETACEOUS BEDS ON VERMILION CREEK, MOFFAT COUNTY, COLORADO

	Feet.
Mesaverde group (part):	
Williams Fork (?) formation:	
White and gray sandstone; gray and drab shale; coal beds; upper part cut off by faulting against Wasatch formation. More than.....	500
Iles (?) formation:	
Massive white sandstone predominant; a little gray shale and carbonaceous shale. At 75 feet above base occur *Halymenites major* Lesquereux, *Inoceramus* sp., *Cardium* sp., *Mactra formosa* Meek and Hayden. About.....	1700

[4] J. B. REESIDE, JR. *Cephalopods from the lower part of the Cody shale of Oregon Basin, Wyoming*. U. S. Geol. Surv. Prof. Paper 150: 1–19. 1927.

Mancos shale:

1. Gray shale, increasingly sandy toward top..... 100
2. Gray to slate-colored shale; at top of unit and 490 feet lower are lines of rusty-brown fine-grained calcareous sandstone concretions several feet in diameter, containing fossils of Montana age. In the upper horizon were noted *Pteria nebrascana* Evans and Shumard, *Baculites* sp., *Lunatia* sp.; in the lower, *Inoceramus barabini* Morton..... 1224
3. Rusty-brown medium-grained sandstone in short lenses at four horizons, separated by gray shale; most prominent lens, 6 feet thick, at base; next, 2 feet thick, 25 feet higher; third, 1 foot thick, 88 feet above base; fourth, 8 feet thick, at top. In the highest lens occur *Inoceramus sagensis* Owen, *Ostrea* sp., *Lucina* n. sp., *Corbula* n. sp., *Teredo* sp., *Volutoderma* n. sp., *Anisomyon* aff. *A. subovatus* Meek and Hayden, *Hamites novimexicanus* Reeside, *Baculites ovatus* Say, *B. asper* Morton, *Scaphites hippocrepis* DeKay, *S. aquilaensis* Reeside, *S. stantoni* Reeside; in the next to lowest, *Inoceramus sagensis* Owen and *Haresiceras natronense* Reeside; in the lowest, *Solemya bilix* White, *Inoceramus* sp., *Ostrea* cf. *O. congesta* Conrad, *Lucina* n. sp., *Corbula* n. sp., *Ichthyodectes?* sp..... 140
4. Gray to slate-colored shale, irregular bedding; a line of gray calcareous septarian concretions at base; thin beds of soft, fine-grained gray sandstone at 647, 657, 1213, 1233, and 1269 feet above base of unit. At 2085 feet above base occur *Lucina* n. sp., *Corbula* n. sp., *Baculites* sp., *Hypsodon? radiatulus* Cockerell; at 1269 feet, *Inoceramus* sp., *Hypsodon? radiatulus* Cockerell; at 657 feet, *Desmoscaphites bassleri* Reeside and *Ichthyodectes?* sp.; at 150 feet, *Pteria gastrodes* Meek, *Inoceramus* sp., *Ostrea congesta* Conrad, *Baculites* sp., *Scaphites vermiformis* Meek and Hayden; at 45 feet, *Baculites codyensis* Reeside; at 35 feet, *Inoceramus* aff. *I. stantoni* Sokolow; at 25 feet, *Lingula* aff. *L. nitida* Meek and Hayden, *Veniella mortoni* Meek and Hayden, *Lucina subundata* Hall and Meek, *Fusus?* sp., *Baculites codyensis* Reeside, *Scaphites ventricosus* Meek and Hayden. In the lowest 400 feet fragments of a large, thick-shelled species of *Inoceramus* (*Haploscapha?*), coated with *Ostrea congesta* Conrad, are abundant; in the next overlying 800 feet they still occur but are rather rare and of smaller size..... 2285

5. Dark slate-colored shale, including five or six bands of fine-grained gray sandstone that weather to low ridges. At 25 feet above base occur *Lucina* sp., *Baculites* sp.; at 15 feet, *Ostrea congesta* Conrad and *Lucina subundata* Hall and Meek. *Inoceramus* (*Haploscapha?*) sp. and *Ostrea congesta* are abundant throughout..... 75

6. Light bluish-gray shale, laminated, breaking into flat pieces when fresh; a line of gray calcareous septarian concretions as much as 1 foot in diameter at base. At 20 feet above base occur *Lingula* aff. *L. nitida* Meek and Hayden, *Nucula* sp., *Yoldia* aff. *Y. scitula* Meek and Hayden, *Arca* n. sp., *Inoceramus* sp., *Ostrea congesta* Conrad, *Lucina subundata* Hall and Meek, *Anchura?* sp., *Anisomyon* n. sp., *Fusus* n. sp., *Baculites asper* Morton; at base, *Inoceramus umbonatus* Meek and Hayden, *Ostrea congesta* Conrad, *Baculites asper* Morton, *Ichthyodectes?* sp. *Inoceramus* (*Haploscapha?*) and *Ostrea congesta* are abundant throughout..... 75

7. Dark slate-colored shale with irregular bedding; zones of light-gray laminated shale; many thin layers of shaly sandstone that weather into papery flakes; lines of gray calcareous septarian concretions as much as 1 foot in diameter at 75 and 90 feet above base of unit; reddish sandy streaks with some reddish concretions at 125 and 190 feet above base. At 215 feet occur *Inoceramus* sp., *Ostrea congesta* Conrad, *Anisomyon* n. sp., *Baculites codyensis* Reeside; at 190 feet, *Inoceramus* aff. *I. stantoni* Sokolow; at 180 feet, *Inoceramus* aff. *I. stantoni* Sokolow, *Ostrea congesta* Conrad, *Lucina* sp., *Baculites codyensis* Reeside, *Helicoceras* aff. *H. corrugatum* Stanton, *Echidnocephalus?* sp., *Leucichthyops vagans* Cockerell (?); at 130 feet, *Inoceramus* aff. *I. stantoni* Sokolow, *I. undulatoplicatus* Roemer, *Ostrea congesta* Conrad, *Baculites codyensis* Reeside; at 125 feet, *Inoceramus* sp., *Ostrea congesta* Conrad, *Sauvagesia* cf. *S. austinensis* (Roemer), *Isurus?* sp.; at 75 feet, *Inoceramus* aff. *I. stantoni* Sokolow, *Baculites* sp., *Scaphites vermiformis* Meek and Hayden; at 55 feet, *Inoceramus* aff. *I. stantoni* Sokolow, *Ostrea congesta* Conrad, *Vanikoro?* sp., *Baculites asper* Morton, *Hypsodon?* sp.; at base, *Inoceramus aff. I. stantoni* Sokolow, *Baculites* sp. *Inoceramus* (*Haploscapha?*) sp. and *Ostrea conaesta* are abundant throughout.... 320

8. Light bluish-gray shale, laminated, breaking into flat pieces when fresh; a line of gray calcareous septarian concretions at 335 feet above base of unit. In the concretions occur *Inocera-*

mus aff. *I. stantoni* Sokolow, *Ostrea congesta* Conrad, *Lucina subundata* Hall and Meek, *Phlycticrioceras oregonense* Reeside, *Scaphites* sp.; at 325 feet, *Inoceramus deformis* Meek, *Ostrea congesta* Conrad, *Baculites asper* Morton; at 295 feet, *Inoceramus deformis* Meek, *I.* aff. *I. stantoni* Sokolow, *Pteria gastrodes* Meek, *Baculites* sp., *Phlycticrioceras oregonense* Reeside, *Helicoceras* cf. *H. corrugatum* Stanton; at 285 feet, *Cyphosoma* n. sp., *Solemya* n. sp., *Inoceramus deformis* Meek, *Inoceramus* aff. *I. stantoni* Sokolow with original color pattern preserved, *Ostrea congesta* Conrad, *Anisomyon?* n. sp., *Baculites asper* Morton, *Phlycticrioceras oregonense* Reeside, *Scaphites ventricosus* Meek and Hayden; at 240 feet, *Inoceramus deformis* Meek, *Ostrea congesta* Conrad, *Baculites* sp., *Scaphites* sp.; at 220 feet, *Inoceramus deformis* Meek, *Inoceramus* aff. *I. stantoni* Sokolow, *Ostrea congesta* Conrad, *Baculites asper* Morton. *Inoceramus* (*Haploscapha?*) sp. and *Ostrea congesta* are abundant throughout..... 430

9. Dark slate-colored shale with irregular bedding. Near top of unit occur *Nodosaria* n. sp., *Inoceramus* aff. *I. stantoni* Sokolow, *Lucina* sp., *Mactra emmonsi* Meek, *Lunatia?* sp., *Anchura* n. sp., *Cerithium?* n. sp., *Baculites* cf. *B. gracilis* Shumard, *Helicoceras* aff. *H. corrugatum* Stanton, *Placenticeras* cf. *P. pseudoplacenta* Hyatt. *Inoceramus* (*Haploscapha?*) sp. and *Ostrea congesta* Conrad are fairly abundant throughout..... 106
10. Large, dark reddish-brown sandstone concretions containing *Inoceramus fragilis* Hall and Meek, *Ostrea* sp., *Scaphites warreni* Meek and Hayden, *Prionocyclus* sp., *Corax* sp..... 1
11. Dark slate-colored shale with irregular bedding..... 315
12. White sandstone, stained somewhat brown on surface; makes a dip slope..... 2
13. Gray and brown carbonaceous shale; lens of coal as much as 18 inches thick..... 4
14. Massive fine to medium grained sandstone; upper part white, lower part buff; slightly cross-bedded; a little gray shale present. Near top of unit occur *Lingula* cf. *L. nitida* Meek and Hayden, *Solemya? obscura* Stanton(?), *Inoceramus* sp., *Mactra* sp., *Corbula kanabensis* Stanton, *Lunatia* aff. *L. concinna* Hall and Meek, *Prionocyclus* sp., *Petalolepis? fibrillatus* Cockerell(?)..... 55
15. Gray sandy shale..... 25

16. Gray fine-grained sandstone in layers 1 to 6 inches thick, and gray sandy shale, interbedded. At middle of unit occur *Inoceramus fragilis* Hall and Meek, *Ostrea* sp., *Scaphites* sp., *Prionocyclus wyomingensis* Meek; at base, *Ptychodus* sp	54
17. Limy shale with cone-in-cone structure	1
18. Hard platy shale; bluish-white to cream-colored on weathered surface, dark brown on fresh surface. Fish scales abundant	34
19. Bentonite	3
20. Hard platy shale; bluish-white to cream-colored on weathered surface, dark brown on fresh surface. Fish scales abundant and at 75 feet above base of unit occur *Inoceramus labiatus* Schlotheim, *Metoicoceras whitei* Hyatt, *Leucichthyops vagans* Cockerell	118
Total thickness	5367
Dakota(?) sandstone:	
Gray coarse-grained sandstone; gritty and conglomeratic bands	50
Gray shale and thin sandstones	15
White medium-grained sugary sandstone, friable	22
Dark-gray shale	24
Light-gray shale, greenish tint	16
White coarse-grained sugary sandstone, friable; contains many black grains	3
White and light-gray conglomeratic sandstone; many zones of small pebbles, mostly of black chert	27
Total thickness	157

Morrison formation.

PALEONTOLOGY.—*A new hypural fan from the Miocene of Maryland.*[1] WILLARD BERRY, Ohio State University (Communicated by JOHN B. REESIDE, JR.)

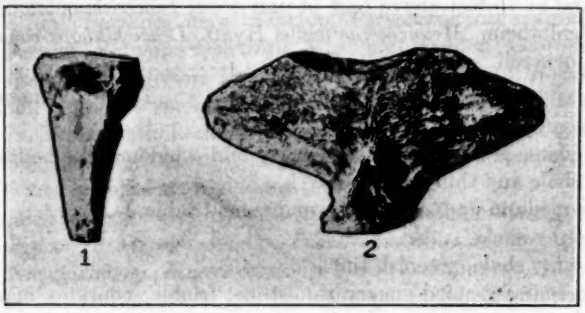
While collecting along the Calvert Cliffs of Maryland this past summer the writer found many fragments of fossil bone. Those worth preserving were turned over to the National Museum at Washington. However, in a chunk of material collected to show the lithology of the formation, a rather well preserved hypural fan was later found that seems worthy of record. The material was from the talus at the base of the cliffs south of Camp Roosevelt, and is probably from the Calvert formation of the Miocene.

The specimen may be described as follows:

[1] Received December 6, 1929.

Xiphias ? drydeni W. Berry, n.sp.

Terminal vertebral centrum moderately concave in front and circular in cross section, its neural and haemal spines fused into a solid fan-shaped body; the anterior haemal spine less completely fused with the next following than are the rest, and separated from it near the point of attachment to the centrum by a perforation 4 mm. in diameter passing completely through the fan and connecting with a perforation of equal diameter on the dorsal side of the anterior haemal spine at the point of attachment to the centrum. There is also a smaller perforation extending posteriorly through the fan. There were apparently lateral processes which have been broken off but the bases are still present on either side of the centrum.



Figures 1–2.—Dorsal and side views, natural size, of the hypural fan of *Xiphias? drydeni* W. Berry, n. sp.

This species cannot be referred to *Xiphias? radiata*, described from the Aquia Formation (Eocene) by Clark,[2] because of the difference in concavity of the front of the centrum and because of the perforation opening above the anterior haemal spine. The extreme height of the fan is 5.6 cm. and the diameter of the centrum is 1.5 cm., the ratio of the two differing greatly from those fans described from the Eocene. This species differs also from those found in the Tertiary of South Carolina in having a circular cross section of the centrum. It is named after Mr. A. L. Dryden, who was with me during the collecting season when it was found.

Occurrence.—Calvert formation (?), Miocene, Calvert Cliffs, Maryland.

The type is in the Geological Museum of The Ohio State University, Accession number 17109.

[2] W. B. Clark. *Eocene deposits of Maryland.* Md. Geol. Survey Rept., p. 112. 1901.

BOTANY.—*Plants of the Appalachian shale-barrens.*[1] EDGAR T. WHERRY, Washington, D.C.

The term shale-barren was appropriately applied by Steele[2] to a unique type of plant habitat occurring locally in the central Appalachians, within the area delimited by two heavy lines on the accompanying map, figure 1. These barrens are developed on shale-slopes,—places where hard shaly rocks of the Romney (middle Devonian) and Jennings (early upper Devonian) formations outcrop on steep hillsides, the surface being strewn with frost-broken fragments. They are typically occupied by a sparse, scrubby growth of pine, oak, mountain-laurel, and other woody plants, with herbaceous ones scattered between, grading into normal woodland wherever conditions permit the accumulation of sufficient soil. A number of endemic species and

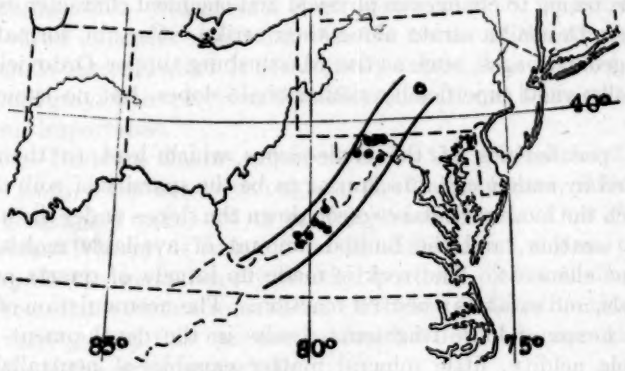


FIG. 1. Location of the Shale-barren Region

varieties have been observed to characterize this shale-barren plant-association, and others no doubt remain to be discovered. As no annotated list of these has ever been published, one is here presented in the hope of encouraging further investigation of the region.

The shale-barrens thus far discovered are located as follows:

Maryland, at intervals along the National Highway, U. S. route No. 40, between Cumberland and Indian Springs (20 miles west of Hagerstown).

Northern West Virginia, similarly along route No. 50 from south of Keyser to Gore, west of Winchester, Virginia.

[1] Received January 4, 1930.

[2] Contr. U. S. Nat. Herb. **13**: 359. 1911.

Southeastern West Virginia, on various hills in the vicinity of White Sulphur Springs, especially the western slope of Kates Mountain, which is reached by a trail from the railroad station; Slaty Mountain, north of Sweet Springs.

West-central Virginia, along state route No. 39 east of Monterey; on various hills in the neighborhood of Hot Springs; along the Chesapeake and Ohio railroad near Millboro, Goshen, and Augusta Springs, and its branch line north of Covington; and near U. S. route 60 west of Covington.

In figure 1 the above listed places are indicated by dots, which apparently fall into two separate groups, although the gap between these merely reflects the relative inaccessibility and consequent lack of exploration of the intervening territory. Further northeast as well as further southwest the shale-slopes rapidly diminish in size and barrenness, owing to changes in physical and chemical character exhibited by these Devonian strata along their strike. Certain formations of other geologic ages, such as the Martinsburg (upper Ordovician) occasionally yield superficially similar shale-slopes, but no typical barrens.

The peculiarities of the shale-slopes which lead to their being occupied by endemic plants appear to be the sparsity of soil, the way in which the loose rock-flakes creep down the slopes under the influence of the weather, and the limited amount of available moisture and nutrient elements. The rock is made up largely of quartz and clay minerals, and exhibits a neutral reaction. The accumulation of humus in the heaps of loose fragments results in the development of considerable acidity, little mineral matter capable of neutralizing the organic acids formed being present. The litter is evidently too porous to permit the accumulation of much available nitrogen, and tests have failed to show the presence of nitrates or ammonia in appreciable amount.

The more notable plants of these habitats are here listed in the standard order followed in manuals of botany, notes being given as to the distribution, relationships, history, etc., of the endemic ones.

Notable Plants of the Shale-barrens.

Cheilanthes.—The Hairy Lipfern, *C. lanosa* (Michx.) Watt, grows on various kinds of rock throughout the southeastern uplands, and invades the barrens wherever cliffs are well-developed. The only peculiarity it shows here is a stunted aspect, owing to the general sterility.

Woodsia.—Abundant evidence has been assembled by Fernald[3] indicating that during pre-Glacial times Rocky Mountain plants migrated eastward across northern North America, and some of these plants found their way down the Allegheny mountain system. One of the latter was the Rocky Mountain Cliff-fern, *W. scopulina* D.C. Eaton, which as recently recorded,[4] is now known from six southeastern stations. Two of these, near Covington and Sweet Springs, are on the cliffs of typical Devonian shale-slopes, the remainder being on more or less similar rocks of other geologic ages. The fronds exhibit features differing to some extent from those of the Rocky Mountain occurrences, and Fernald has suggested that the differences may be of specific rank, although in view of the variability of the species, it seems more probable that this Allegheny Cliff-fern should be classed only as a variety.

Selaginella.—The widespread Rock Spikemoss, *S. rupestris* (L.) Spring, varies in aspect somewhat with the nature of the substratum. On the shale-barrens, which it occasionally enters, it is often relatively slender and grayish in color, but the differences are not believed to be of taxonomic importance.

Allium.—Nodding Onions, grouped under the general head of *A. cernuum* Roth, occur nearly throughout the United States, falling into several geographic races, not as yet fully worked out. One of these, *A. oxyphilum* Wherry, is endemic in the shale-barren region, usually occurring on the more heavily wooded portions of the shale-slopes, though sometimes remote from them. Perhaps it should be classed as only a variety, but this can not be decided until someone makes a field study of the group as a whole.

Eriogonum.—This typical Rocky Mountain genus has very few representatives in the east, but one of the latter, *E. alleni* Wats., is a highly characteristic member of the shale-barren flora. The Yellow-buckwheat, as it is locally called, prefers the barest and most sterile situations, its long tough roots penetrating crevices in the shale rocks and holding the clumps in place in spite of the downward creep of the surface fragments. Its ancestors presumably crossed the continent and came down the Alleghenies during pre-Glacial times, but subsequent climatic changes destroyed all traces of them, leaving behind this single endemic species.

[3] Mem. Amer. Acad. Arts Sci. 15: 239. 1925.
[4] Amer. Fern. Journ. 19: 101. 1929.

Polygonum.—One of the dry-soil Knotweeds, apparently *P. tenue* Michx., is abundant in the more open parts of the barrens.

Anychia.—Several members of this genus occur on sterile gravelly soils in many parts of the eastern United States, and naturally invade the shale-barrens. The one which becomes most conspicuous in these habitats, though without exhibiting any consequent morphologic changes, is *A. divaricata* Raf. This has often been regarded as identical with *A. polygonoides* Raf., but, as pointed out by Steele,[5] is undoubtedly distinct.

Paronychia.—Only one Nailwort has been observed on shale-slopes, the Texan species, *P. dichotoma* (L.) Nutt., which is known in the eastern states in few localities.

Silene.—The Pink Catchfly, *S. pennsylvanica* Michx. or *S. caroliniana* Walt., growing as it does in gravelly soil in so many places, could not fail to invade the shale-barrens. So far as known no significant change results, although the plants are often rather stunted in aspect. One of the many forms of Fire Catchfly, *S. virginica* L. is also occasional in these habitats; it does not seem to be an endemic type, although the variations of this species remain to be interpreted.

Anemone.—On the more heavily wooded shale-slopes one or more members of the section *Anemonanthea* of this genus occur, but their identity has not been worked out. Perhaps only forms of *A. lancifolia* Pursh (*A. trifolia* of current manuals) are represented, although it seems quite probable that the imperfectly known *A. minima* DC. is a member of the same flora, and has been largely overlooked owing to the fact that little collecting has been done in these regions in early Spring.

Clematis.—Members of the section *Viorna* of this genus are present on several shale-barrens, but their relationships are obscure. In 1814 Pursh had described *C. ovata* from the mountains of South Carolina, and Britton[6] concluded this to be identical with the plant of the Kates Mountain shales, although the published description of the type specimen indicates that it is too incomplete to justify considering this as established. The Clematis of the Millboro barren was described by Steele in 1911 as *C. viticaulis*, and matters are still further complicated by the occurrence on others of *C. sericea* Michx., which is usually supposed but not known to be the same as *C. ochroleuca* Ait. of Atlantic lowland regions. Before this tangle can be unravelled it will be neces-

[5] Contr. U. S. Nat. Herb. **13**: 363. 1911.
[6] Mem. Torr. Bot. Club **2**: 28. 1890.

sary to study all of these plants in fresh condition, make sure as to the identity of Michaux's and Pursh's species by exploration of the type localities, and find out the extent of variability within the individual colonies. This would make an interesting study for someone who has the opportunity to carry on the necessary field work.

Arabis.—An endemic derivative of the widespread Smooth Rock-cress, *A. laevigata* (Muhl.) Poir., grows on the shale-barrens, being remarkable in blooming in Summer instead of Spring. It has been named *A. serotina* by Steele, but its relationships to other variants of the species remain to be worked out.

Draba.—The little Rock-twist, *D. ramosissima* Desv., grows on cliffs of many kinds of rock in the southeastern uplands, and enters the shale-barrens on the more sheltered ledges, without exhibiting any resulting morphologic effects.

Sedum.—Three of the Stonecrops of the Allegheny region occur to some extent on shale slopes: American Live-for-ever, *S. telephioides* Michx.; Triplet Stonecrop, *S. ternatum* Michx.; and Mountain Stonecrop, *S. nevii* Gray, the last being most characteristic of these habitats. None of them show, however, any recognizable changes on passing from one type of rock to another, which they do freely.

Trifolium.—The most chacteristic endemic of the shale-barrens is the Longleaf Clover, *T. virginicum* Small. This is a derivative of the Buffalo Clover, *T. reflexum* L., which grows on the western slopes of the Alleghenies and further west, and was reduced to a variety, *T. reflexum virginicum*, by McDermott.[7] The latter author stated it to be "abundant throughout the Appalachian mountains", although for many years but one locality was represented in herbaria. Up to early in 1929, eight stations for it had been definitely made known,[8] another since reported in Mineral County, West Virginia, bringing the total to nine. It favors the barest and most sterile situations, withstanding the instability of the surface fragments by sending long tough roots into crevices in the more solid rock below.

Astragalus.—A small member of this genus is well developed on a few of the shale-barrens; it has also been found on limestone in Frederick County, Virginia, by Hunnewell.[9] This agrees fairly well with *A. distortus* T. & G., but may be varietally distinct from the species as developed in the central United States—Texas to Iowa and eastward, but not coming within 400 miles of the shale-slope region.

[7] *North American Species Trifolium*, p. 273. 1908.
[8] Torreya **29**: 105. 1929.
[9] Rhodora **31**: 256. 1929.

Viola.—The Birdsfoot Violet, *V. pedata* L., is a typical occupant of sterile gravelly soils in many parts of the eastern states, and would naturally be expected to invade the shale-barrens. When it does, its leaves exhibit a distinctive type of cutting, but whether it also differs in other characters has not been ascertained.

Oenothera.—Both an unusually small and an unusually large flowered representative of the section *Onagra* of this genus grow on shale-slopes. The former was suggested by Steele[10] to be *O. parviflora* L., but has not been sufficiently studied. The latter is, however, an endemic species, *O. argillicola* Mackenzie. When this remarkable Evening-primrose is in bloom in late Summer, its habitats seem rather inappropriately classified as barrens, for it makes a magnificent floral display. It is, however, rather closely restricted to sterile situations, having, for a biennial, an unusually extensive root system. An interesting outlying occurrence of it has been noted, along the Juniata River opposite Losh Run station, in Perry County, Pennsylvania (marked by a circle on the map, Fig. 1); this has unfortunately been destroyed by the construction of U. S. Highway No. 22. The rock there is a shale of the same geological age as that underlying the more southern shale-barrens, but apparently too rich in lime and other plant-food elements, or too readily weathered into soil, to favor the growth of other endemics.

Pseudotaenidia.—*P. montana* Mackenzie, or, as it may be called, the Mountain-pimpernel, represents not only an endemic species but also an endemic genus, no near relatives being known anywhere. Few localities of it appear to be on record, but it is not uncommon in woods on shale-slopes. The occurrence reported near Luray, Virginia, was no doubt on the shale there, which though resembling the Devonian rock in appearance, is actually of another geologic age, and differs so much in composition as to yield no typical barrens.

Asclepias.—Several common milkweeds of sterile gravelly soils enter the shale-barrens, including *A. quadrifolia* Jacq., *A. verticillata* L., and *A. tubersoa* L. The last named often has abnormally pale corolla-color in such habitats, but no other differences have been recognized.

Convolvulus.—The widespread Dwarf Convolvulus, *C. spithamaeus* L., exhibits considerable geographic variation, the details of which remain to be worked out. One of its derivatives, which may be termed the Velvet Convolvulus because of the strikingly velvety leaves, appears to be particularly well adapted to shale-barren habitats, where it locally forms vast patches of more or less regularly spaced stalks,

[10] Contr. U. S. Nat. Herb. 13: 366. 1911.

to the exclusion of most other vegetation. As recently pointed out,[11] this is apparently *C. stans* Michx., the type locality of which was in Canada, near Lake Champlain. It is noteworthy that shale rocks, similar in aspect to those of the region under discussion, occur in this vicinity, although for that matter the plant is not entirely restricted to such rocks, for specimens have been seen in herbaria from Ducktown, Tennessee, and Atlanta, Georgia, where very different formations are represented. Further field study of this group is much to be desired.

Phlox.—Festoons of Moss-Phlox drape the ledges on many of the shale-slopes, the white or pale lavender flowers with which they are covered in Spring giving them a different aspect from the related material of other habitats, and the name *P. brittonii* Small has been applied. A detailed study[12] has shown, however, that in view of the marked variability of this group of Phloxes, the differences can not be regarded as having more than varietal significance, leading to the combination *P. subulata brittonii.* Besides growing on shale, this plant extends down the Potomac valley nearly to Washington, D. C., on other types of rock.

A highly distinctive species, termed the Sword-leaf Phlox from the shape of its evergreen basal leaves, and recently named *P. buckleyi* Wherry, is included in this enumeration because, although not growing on barrens, it seems to thrive best in woods near the bases of shale-slopes. It is an endemic relative of the more widespread Mountain Phlox, *P. ovata* L., which enters the same habitats to some extent without, however, exhibiting any recognizable morphologic changes.

Penstemon.—The Mountain Penstemon, *P. canescens* Britton, thrives on sterile gravelly slopes throughout the southeastern uplands, and naturally invades the shale-barrens. When it does so, the corolla color seems to be paler than usual, although no other distinctive features are known to have developed.

Houstonia.—Several species of Summer-bluets grow in the shale-slope region, and *H. tenuifolia* Nutt. becomes particularly abundant in these habitats, showing no differences from occurrences on other formations.

Campanula.—The lovely little Allegheny Bluebell, *C. divaricata* or *C. flexuosa* Michx., thrives on various types of rocks in the Appalachians, including the shales here under discussion. Its characters remain, however, essentially uniform throughout.

[11] Torreya **29**: 106. 1929.
[12] Bartonia **11**: 27. 1929.

Liatris.—Gayfeathers are a striking feature of several of the shale-barrens, but their nomenclature needs further consideration. Perhaps the commonest is a derivative of *L. spicata* (L.) Willd., which corresponds more or less to *L. spicata montana* Gray.

Solidago.—One of the several goldenrods of these habitats, an apparent relative of *S. arguta* Ait., has been described as a distinct species, *S. harrisii* Steele. Others also deserve critical study.

Aster.—The widespread *A. lowrieanus* is represented on the barrens by a plant with creeping rootstocks which adapt it to growth in the heaps of loose shale, and it has received the appropriate name of *A. schistosus* Steele. Other species of this genus also occur in these habitats, but show no recognizable changes there. The latter statement apparently applies as well to the Antennarias, although they have not been investigated closely.

Silphium.—Rosinweeds are mostly native to the prairies of the central United States, but a few of them push eastward into the Alleghenies. One of these, *S. reniforme* Raf., is a striking member of the shale-barren flora, although it grows to some extent on other formations as well.

Helianthus.—Several Sunflowers occur on or near shale-barrens, but the only one recognized as showing distinctive characters is a rough-leaved representative of a widespread species, which has been named *H. laevigatus reindutus* Steele.

Senecio.—Three or four Groundsels are known in the shale-slope region, one of them being especially noteworthy. The Everlasting-Groundsel, *S. antennariifolius* Britton, is a highly characteristic occupant of the barer situations, often spreading into large patches, and having been but rarely observed in any other habitats. This endemic, like several others, is most nearly related to a Rocky Mountain species, and in the key in Gray's Manual, ed. 7, the range is actually the only feature used to distinguish it from *S. canus* Hook. (*S. purshianus* Nutt.) of that region.

In conclusion, two tabular arrangements of the species above discussed may be given to bring out certain interesting points about them: (1) a geographic list, showing the inferred sources of the plants and the type of endemism they represent; and (2) a chronologic list of the articles in which the more pronounced endemics have been described, showing how this interesting flora has been critcally studied only at more or less long intervals.

TABLE 1. GEOGRAPHIC LIST OF PLANTS OF THE SHALE-BARRENS[13]

Without near relatives:	*Pseudotaenidia montana*
Derived from Rocky Mountain species:	*Woodsia scopulina* var.? *Eriogonum alleni* *Senecio antennariifolius*
Derived from prairie species:	*Trifolium reflexum virginicum* *Astragalus distortus* var.? *Silphium reniforme*
Derived from surrounding species:	*Allium oxyphilum* (from *A. cernuum*) *Arabis serotina* (from *A. laevigata*) *Anemone* spp. *Clematis* spp. *Viola pedata* var.? *Oenothera argillicola* (from *O. biennis*) *Convolvulus stans* (from *C. spithamaeus*) *Phlox subulata brittonii* *Phlox buckleyi* (from *P. ovata*) *Liatris spicata montana*? *Solidago harrisii* (from *S. arguta*) *Aster schistosus* (from *A. lowrieanus*) *Helianthus laevigatus reindutus*
Entering without essential change:	*Cheilanthes lanosa* *Selaginella rupestris* *Polygonum tenue* *Anychia divaricata* et al. *Paronychia dichotoma* *Silene pennsylvanica* et al. *Draba ramosissima* *Sedum nevii* et al. *Oenothera parviflora*? *Asclepias tuberosa* et al. *Phlox ovata* *Penstemon canescens* *Houstonia tenuifolia* et al. *Campanula flexuosa* *Aster* spp. *Antennaria* spp. *Helianthus* spp. *Senecio* spp.

[13] This is by no means a complete list of the plants which grow on the barrens, but does include most of the more striking or noteworthy ones thus far observed. Further study will no doubt result in adding to the list, as well as in shifting of some species from the category "entering without essential change" to other classes.

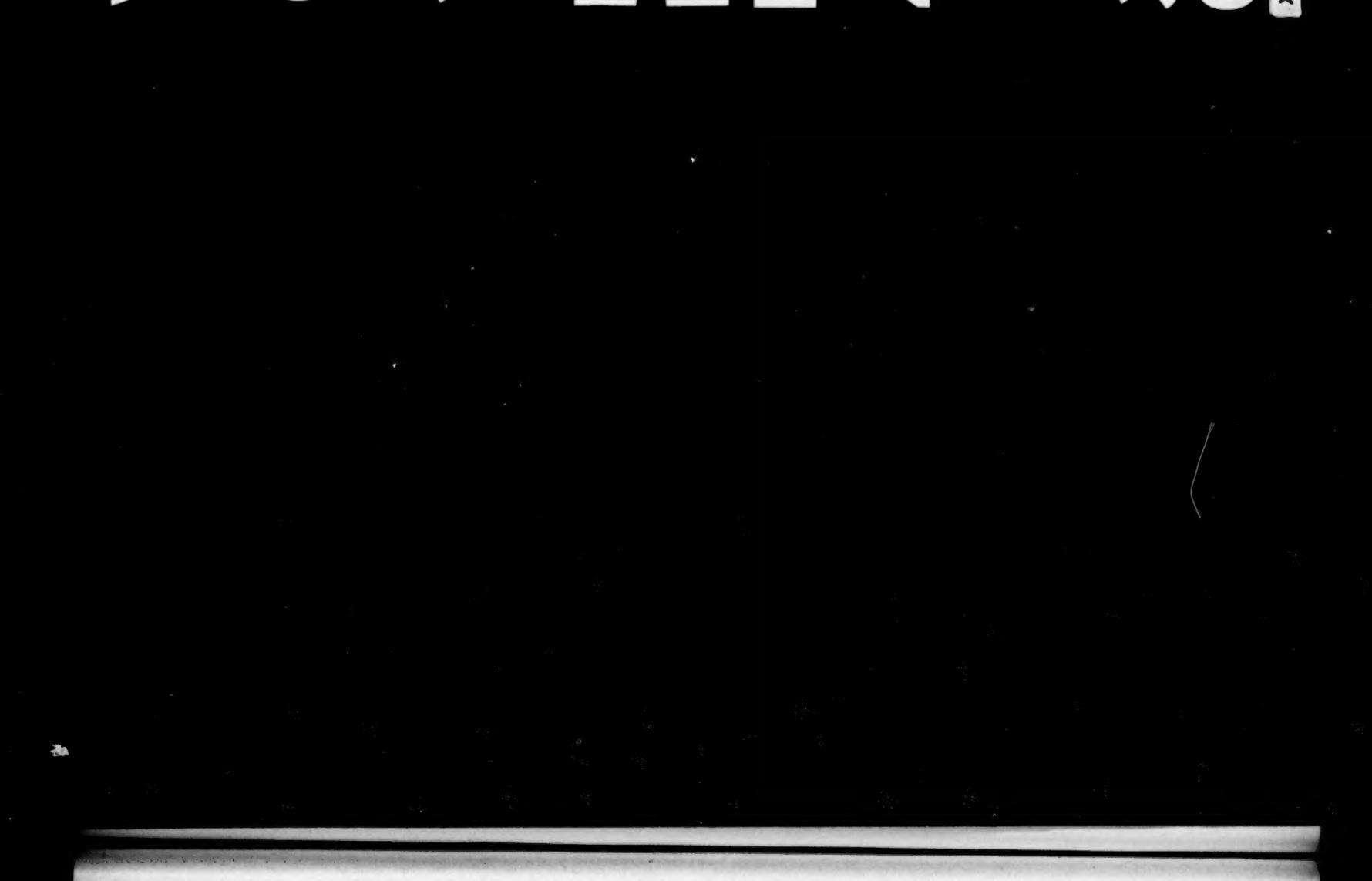
TABLE 2. CHRONOLOGICAL LIST OF SHALE-BARREN ENDEMICS OR NEAR-ENDEMICS

1803.	MICHAUX, Flora Boreali-Americana **1**:	136.	*Convolvulus stans.*
		319.	*Clematis sericea.*
1814.	PURSH, Flora America Septentrionalis **2**:	736.	*Clematis ovata.*
1841.	RAFINESQUE, Trans. Amer. Phil. Soc. n. s. **7**:	342.	*Silphium reniforme.*
1889.	WATSON, in Gray's Manual, ed. **6**, p.	734.	*Eriogonum alleni.*
1894.	SMALL, Mem. Torr. Bot. Club **4**:	112.	*Trifolium virginicum.*
1898.	BRITTON, in Britton & Brown Illustr. Flora **3**:	478.	*Senecio antennariifolius.*
1900.	SMALL, Bull. Torr. Bot. Club **27**:	279.	*Phlox brittonii.*
1903.	MACKENZIE, Torreya **3**:	159.	*Pseudotaenidia montana.*
1904.	MACKENZIE, Torreya **4**:	56.	*Oenothera argillicola.*
1911.	STEELE, Contr. U. S. Nat. Herb. **13**:	364.	*Clematis viticaulis.*
		365.	*Arabis serotina.*
		369.	*Solidago harrisii.*
		373.	*Aster schistosus.*
		374.	*Helianthus laevigatus reindutus.*
1925.	WHERRY, THIS JOURNAL **15**:	370.	*Allium oxyphilum.*
1929.	WHERRY, THIS JOURNAL **20**:	25.	*Phlox buckleyi.*

SCIENTIFIC NOTES AND NEWS

The largest single monetary award in America for scientific accomplishment has been created by Popular Science Monthly, which, beginning this autumn, will confer an annual prize of $10,000, accompanied by a gold medal, upon the American citizen who has been responsible, during the preceding year, for the achievement in science of greatest potential value to the world.

The award will be bestowed under the auspices of the Popular Science Institute, a research organization maintained by the magazine, of which Prof. COLLINS P. BLISS, associate dean, New York University, is director. The Institute has enlisted the services of twenty-four leaders in American science to serve as a Committee of Award, whose task it will be to select the prize-winning effort. The prize will be conferred for the first time in September, 1930, and the initial period of scientific accomplishment to be considered by the Committee of Award will be the twelve months ending June 30,1930. All scientific workers, professional and amateur, academic and commercial, are eligible.

The Committee of Award consists of: Dr. CHARLES G. ABBOT, Prof. COLLINS P. BLISS, Dr. SAMUEL A. BROWN, Dr. GEORGE K. BURGESS, Dr. WILLIAM W. CAMPBELL, Dr. HARVEY N. DAVIS, Dr. ARTHUR L. DAY, Dr. E. E. FREE, TRAVIS HOKE, Dr. FRANK B. JEWETT, Dr. VERNON KELLOGG, CHARLES F. KETTERING, Dr. ARTHUR D. LITTLE, Dr. JOHN C. MERRIAM, Dr. ROBERT A. MILLIKAN, Dr. HENRY FAIRFIELD OSBORN, Dr. ELMER A. SPERRY, Dr. SAMUEL W. STRATTON, Dr. ELIHU THOMSON, Dr. EDWARD R. WEIDLEIN, HENRY HERMAN WESTINGHOUSE, Dr. ALBERT E. WHITE, Dr. WILLIS R. WHITNEY, and ORVILLE WRIGHT.

The creation of this award, it is expected, will serve to further stimulate scientific and inventive activity in this country, especially along practical lines.